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IMPROVING YIELD AND QUALITY OF SOME NEW POTATO VARIETIES IN WINTER PLANTATION USING ORGANIC STIMULATORS

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ABSTRACT

Field experiments were carried out at El-Baramoon Research Station, Mansoura, Dakahlia Governorate, Egypt (+ 7m altitude, 30º 11- latitude and 28º 26- longitude), during winter seasons of 2007/08 and 2008/09, to study the use of various biostimulants, i.e., humic acid (3 ml l^{-1}), seaweed extract (4 g l^{-1}) and amino acids (5 ml l^{-1}) and/or 50% of recommended NPK fertilizers as well as control (100% NPK) on some new potato cultivars (Alaska, Fridor and Oceania) and Spunta when cultivation in low temperature in order to prolong the export season, which are equivalent free radicals in cells and plant tissue leading eventually to further stimulate with potato plants to low temperature conditions (cold stress), and improved the productivity, yield quality and superoxide dismutase SOD activity. Research also aimed to reduce reliance on chemical fertilizers.

The obtained results revealed that potato cultivars differed significantly in all studied characters. Spunta cv. had more fresh and dry weights per plant, leaf area, tuber yield and yield components, nitrate content and SOD activity, followed by Oceania cv., in both seasons. On the other hand, Fridor and Oceania cv_s had significant higher dry matter, specific gravity, NK-uptake, and starch content than other two cv_s. There were insignificant differences among cv_s in P-uptake and nitrite content. Meanwhile, Alaska cv. gave the highest reducing sugars in comparison with other cv_s.

Application of seaweed as foliar spray + 50% of recommended NPK gave rise to a significant increase in most of the studied characters, i.e., fresh weight, dry weight, leaf area, total tuber yield, number of tuber per plot, average tuber weight and tuber weight > 50 mm, in both seasons. Moreover, foliar application of humic acid or seaweed extract plus NPK 50% significantly increased tuber quality, i.e., tuber dry matter, specific gravity and starch content and reduced significantly reducing sugars, in two seasons of study. Meanwhile, NPK-content (both seasons) and SOD (1st season) was significantly increased when potato plants treated with humic acid + NPK 50%. On the other hand, addition of organic stimulators plus 50% NPK significantly decreased NO_3^- and NO_2^- content in potato tubers, compared with full or half dose application of NPK at both seasons of study.

The interaction between potato cv_s and application of organic stimulators plus inorganic fertilizers had significant effects on all characters in both seasons of this study. The most effective treatments were Spunta cv. x SW + $NPK_{50\%}$ and Fridor cv. x HA + $NPK_{50\%}$.

This study suggests that seaweed extract or humic acid as foliar application plus half dose of recommended NPK on potato plants in the winter season are the most effective treatments for high productivity and quality associated with integrating organic stimulators and inorganic fertilizers, which represents an environmentally and agronomically sound management strategy. Also our results indicate that increased SOD activity due to application of stimulants improved physiological health, protected plants against cold stress, reduced stander fertilizer, while maintaining adequate growth and productivity of potatoes.

Keywords: Potato, biostimulants, seaweed, amino acids, productivity, cultivars.

INTRODUCTION

Disadvantageous conditions such as low temperatures or chilling stress directly affect on potato crop growth and tuberization. Cold stress during winter season, i.e., December and January, may increase oxidative stress leading to cellular damage and growth reduction of cool-season plants (Brussaard *et al.*, 2007). It is well established that environmental stress may damage plants through production of reactive oxygen species (ROS) including superoxide, hydrogen peroxide, hydrogel anions, and singlet oxygen (Scandalios, 1997). It is very strong oxidizing substances, and considers one of the most important factors leading into the entry of plants in the senescence by stimulating harmful biological oxidations of biomolecules (DNA molecules). Moreover, demolition of the membranes occur cellular damage, leading to severe disruption in processes of metabolism, damage photosynthetic function and an irreversible dysfunction or compensated, ultimately destroying cells and finally death of the plant (Dat *et al*., 2000; Ji-Ping, 2007). Plant antioxidant metabolites and enzymes protect plant cells by scavenging these ROS (Polle, 1997). Superoxide dismutase is an efficient antioxidant enzyme for scavenging superoxide anions (Scandalios, 1997).

A variety of organic materials such as humic substances, seaweed extract and amino acids are being used as fertilizer supplements in potato management and are widely used in various biostimulant product formulations. These compounds have been reported to contain phytohormones and osmoprotectants such as cytokinins, auxins, polyamines, and betaines. Manufacturer claims are that these products may be used as a new standard fertility programs by reducing mineral nutrient requirements while improving stress tolerance. Seaweed (*Ascophyllum nodosum* Jol.) extracts (SW), humic acid (HA) and amino acid (AA) are three novel materials that have shown promise for protecting plants against oxidative stress (Zhang *et al*., 2003). Further research indicated that improved stress resistance was associated with increase in antioxidant contents and activities (Zhang and Schmidt, 2000; Blokhina *et al*., 2003; Palta and Karim, 2006).

Fike *et al*. (2001) reported that SW derived from *A. nodosum* contains various compounds including amino acids and micronutrients; they also reported hormonal activity equivalent to 50 mg L^{-1} kinetin. Additionally, three betaine forms have been quantified in *A. nodosum* extracts (Blunden *et al*., 1986) and kahydrin and alganic acid (Spinelli *et al*., 2010). Quarternary ammonium compounds such as betaines are thought to play a pivotal role in plant cytoplasmic adjustment in response to osmotic stresses (Rhodes and Hanson, 1993). Blunden and Wildgoose (1977) mentioned that foliar application of an aqueous seaweed extract of known cytokinin activity produced a significant increase in the yield of potatoes of the variety King Edward. Lung (1996) found that total tuber yields of potato were increased by 12-20% where the algal preparation was applied compared with the control due to an increase in the number of tubers/ha and a reduction in the proportion of small tubers (> 3.5 cm). Lopez-Mosquera and Pazoas (1997) indicated that potato yield was significantly increased when plants treated with seaweed extract compared to the other treatments. Finally, Riley (2002) found that, in the absence of fertilizer, potato yield was increased by 30% and 70% with the use of algal fibre at the rate of 20 and 40 Mg ha^{-1}, respectively. These increases declined to 7% and 17% at the highest rate of fertilizer application (120 kg N, 55 kg P and 187 kg K ha^{-1}).

Humic acid (HA) is the major acid extractable component of humic substances, which consist of hydrophobic framework of aromatic rings linked by flexible carbon chains, with alcohol, amide, amine, carboxylic, carbonyl, phenol, and quinine functional groups (Davies and Ghabbour, 1988). Several researchers have noted that various sources of HA may improve plant nutrient uptake (Adani *et al*., 1998; Bryan and Stark, 2003), increase root growth (Chen and Avaid, 1990; Clapp *et al*., 1998), enhance enzyme activity, and promote stress tolerance (Chen and Avaid, 1990; Mikkelsen, 2005). Liu *et al*. (1998) reported that 400 mg L^{-1} humic acid, supplied hydroponically, enhanced net photosynthesis, root dehydrogenase activity, and root mass of creeping bentgrass. Shankle *et al*. (2004) indicated that application of humic acid plus nutrients increased total marketable yield (US No.1) of sweet potato than the standard fertility program. Seyedbagheri and Torell (2001) found that applied humic acid at 84 kg ha^{-1} increased potato yield, increased soil fertility, improved tilth and facilities aeration and water penetration, they also, found that the highest yields of the grown crops were obtained when humus content in the soil was 2.3-2.5%.

Amino acids (AA) are best known as the building blocks of protein, and that is the main function of the 20 amino acids that are commonly found in proteins. Amino acids as organic nitrogenous compounds stimulated cell growth acting as buffers maintaining favorable pH value within the plant cell as well as synthesizing other organic compounds, such as protein, amines, purines and pyrimidines, alkaloids, vitamins, enzymes, terpenoids and others (Goss, 1973). The requirement of amino acids in essential quantities is well known as a means to increase yield and overall quality of crops. The application of amino acids for foliar use is based on its requirement by plants in general and at critical stages of growth in particular. Plants absorb amino acids through stomata and are proportionate to environment temperature (Lipson and Nasholm, 2001). The application of amino acids before, during and after the stress conditions supplies the plants with amino acids which are directly related to stress physiology and thus has a preventing and recovering effect (Yu *et al*., 2002). Foliar and root application of commercial amino acids products from animal origin led to serve tomato plant growth depression, on the contrary, shoot and root fresh weights were not affected by addition of plant origin amino acids product (Cerdan *et al*., 2006). Awad *et al*. (2007) showed that foliar application of glycine and lysine (100 ppm) either alone or in combination significantly increased dry matter content in potato plants comparing with control plants.

Therefore, the objectives of this research were to investigate the influence of applications of seaweed (SW) extract, humic acid (HA), and amino acid (AA) and/or 50% of recommended NPK as well as full dose of NPK on productivity, quality and superoxide dismutase (SOD) activity of some new potato cultivars during winter season (cold stress).

MATERIALS AND METHODS

Field experiments were conducted at El-Baramoon Research Station, Mansoura, Dakahlia Governorate, Egypt (+ 7m altitude, 30° 11⁻ latitude and 28° 26⁻ longitude), during winter seasons of 2007/08 and 2008/09, to study the effect of adding humic acid HA (3 ml l^{-1}), seaweed extract SW (4 g l^{-1}) and amino acids AA (5 ml l^{-1}) as foliar application and/or 50% of recommended NPK fertilizers as well as control (100% NPK) on growth, yield and yield components as well as chemical composition of some new potato cultivars, i. e., Alaska, Fridor, Oceania and Spunta. The soil type under study was clay loam, with the mechanical and chemical analysis as shown in the following Table (1) according to Page (1982). The average monthly air temperature during the period of study was shown in Table (2). Data were taken by Sakha meteorological station.

Table 1: Some physical and chemical properties of the experimental soil.

Physical properties	Value		Chemical properties	Value	
	1st season	2nd season		1st season	2nd season
Sand (%)	26.8	26.1	pH value	8.0	7.8
Silt (%)	31.7	32.1	EC $dSm^{-}1$(in soil paste)	0.8	0.9
Clay (%)	41.5	41.8	Total N (%)	0.04	0.03
Texture class	Clay-loam	Clay-loam	Available P (ppm)	11.5	11.8
$CaCO_3$	3.2	3.0	Available K (ppm)	312	305
Organic matter (%)	1.2	1.4			

Table 2: Average air temperature from 2007 to 2009 in the experimental district.

Month	Average temperature ° C	
	Max.	Min.
November	24	14
December	19	11
January	18	9
February	20	10
March	24	10

Whole seed tuber of potato (*Solanum tuberosum* L.) were planted on November of 15th and 20th of each season, respectively, at a spacing of 25 cm within rows and 70 cm between rows in three-row plots, 5 m in length.

A split plot system in randomized blocks design was used with three replications. The main plot consisted of potato cultivars, while, sub-plots were treated with organic stimulators with NPK-fertilizers. Humic acid containing 86% humic acid + 6% K_2O + 1% of each Fe, Zn and Mn + 0.5% Mg + 200 ppm Cu; seaweed soluble extract powder of *Ascophyllum nodosum* and containing organic matter 50% + mineral elements (1% N, 18.5% K_2O, 6% P, 0.16% Fe, 0.17% Ca, 0.42% Mg, 2.2% S, 0.08% Mn, 0.03% Cu, 0.04% B, and 0.005% Co), alginic acid 10% + natural plant growth regulators PGRs+

vitamins (mg/100ml) (B1, 0.08; B2, 2.4; B6, 1.2; B12, 0.82; folic acid, 4.2; pantothenic acid, 0.53 and niacin, 1.14) + amino acids + betaines and mannitol, and mixture of amino acids (mg/100ml) (aspartic acid, 249; therionine, 45; serine, 56; glutamic, 55; glycine, 50; alanine, 100; proline, 38; valine, 68; cystine, 44; methionine, 18; iso-lucine, 52; tyrosine, 38; phenylalanine, 32; histedine, 12; lycine, 40; arginine, 20 and tryptophane, 20) + organic acids were used as foliar treatments, in this respect. These supplements were mixed with distillated water and the solutions were applied evenly over each plot at 35 ml m^{-2} using a hand pressure sprayer. Both HA and AA were obtained from Egyptian Fertilizer Development Center, Mansoura, Egypt. Meanwhile, SW was obtained from Sidasa Egypt Company. Spraying was carried out twice applications at 45 and 60 days after planting.

Single superphosphate (15.5% P_2O_5) was added once during soil preparation at the rate of 75 kg P_2O_5 fed^{-1}. Potassium sulphate (48% K_2O) was used in two equal doses with the 2nd and 3rd doses of ammonium nitrate at the rate of 96 kg K_2O fed^{-1}.

Ammonium nitrate (soluble form) was added at three equal doses, i. e. the first after emergence, and second and third doses were applied with 2nd and 3rd irrigation, respectively. Other agricultural practices were carried out according to the recommendation of Ministry of Agriculture, Egypt.

At 70 days after planting (DAP), a random sample of four plants was taken from each experimental unit to determine the growth parameters of potato plants (fresh and dry weights/plant and leaf area/plant). At the harvesting time (115 DAP), the tuber yield fed^{-1}, number of tuber/plot, average tuber weight and tuber weight $plot^{-1}$ were recorded. A representative sample of 10 to 15 healthy tubers from each experimental plot was selected from the largest sizes to obtain quality data (dry matter, specific gravity, starch, reducing sugar and nitrate and nitrite content) according to the methods described by (AOAC, 2000). Nitrogen, phosphorus and potassium accumulation in tubers were estimated based on dry matter and element percentage using the methods described by Cottenie *et al*., (1982). Fresh tuber samples of each cultivar and biostimulants were used to determine SOD. Superoxide dismutase activity was analyzed according to the procedure of Giannopolitis and Ries (1977).

Data obtained were subjected to statistical analysis by the technique of analysis of variance (ANOVA) according to Snedecor and Cochran (1982). Comparisons among means of treatments were tested using Duncan multiple range test.

RESULTS AND DISCUSSION

Vegetative growth:

Cultivars.

The results of this study indicate that there were significant differences among cultivars in all vegetative growth characters (Table 3).

Potato plants cv_s Alaska, Fridor and Oceania and Spunta grown during winter seasons of 2007/08 and 2008/09, naturally exposed to low temperature extremes prevailing in these seasons (Table 2). However, Spunta cv. gave more fresh and dry weights per plant and leaf area per plant as compared with other cultivars, in both seasons. Meanwhile, Fridor cv. gave the lowest values of vegetative growth parameters.

Differences among varieties may be related to their genetical constitution.

Table 3: Vegetative growth characters of potato plant as affected by varieties, NPK plus organic stimulators and their interactions in 2007/08 and 2008/09 seasons.

Treatments		Fresh weight/plant (g)		Dry weight/plant (g)		Leaf area/plant (cm^2)	
		2007/08	2008/09	2007/08	2008/09	2007/08	2008/09
Varieties:-							
1.Alaska		368.95 c	360.69 b	27.15 c	33.20 c	4496 c	4609 b
2.Spunta		440.92 a	396.61 a	39.84 a	38.87 a	4619 a	4728 a
3.Fridor		284.58 d	344.24 b	24.24 d	31.14 d	4453 c	4567 b
4.Oceania		416.99 b	382.14 a	35.98 b	35.74 b	4561 b	4671 a
NPK + Organic stimulators:-							
1.NPK 100%		396.35 a	334.57 d	33.93 a	33.04 d	4346 d	4493 d
2.NPK 50%		357.07 e	288.28 e	28.30 d	25.67 e	4224 e	4294 e
3.NPK$_{50\%}$ + HA		381.16 c	410.10 b	32.43 b	37.90 b	4704 b	4815 b
4.NPK$_{50\%}$ + SW		391.96 b	438.18 a	33.91 a	41.13 a	4809 a	4869 a
5.NPK$_{50\%}$ + AA		362.77 d	383.81 c	30.46 c	35.95 c	4579 c	4747 c
Interaction:-							
Alaska	1.NPK 100%	385.76 j	327.26 m	28.80 h	30.11 l	4320 h	4422 k
	2.NPK 50%	350.10 n	280.16 p	25.60 k	25.50 p	4228 j	4276 m
	3.NPK$_{50\%}$ + HA	368.11 l	390.11 h	26.17 ij	36.18 g	4592 de	4770 f
	4.NPK$_{50\%}$ + SW	380.06 k	429.23 d	28.92 h	40.00 d	4760 c	4840 d
	5.NPK$_{50\%}$ + AA	360.70 m	376.67 i	26.26 i	34.23 h	4580 e	4735 g
Spunta	1.NPK 100%	463.15 a	350.20 k	42.20 a	42.14 c	4418 g	4613 i
	2.NPK 50%	411.30 g	308.70 n	36.26 e	27.20 n	4276 i	4370 l
	3.NPK$_{50\%}$ + HA	448.32 c	453.83 b	40.36 b	42.76 b	4886 a	4910 b
	4.NPK$_{50\%}$ + SW	460.22 b	462.10 a	42.18 a	43.18 a	4903 a	4939 a
	5.NPK$_{50\%}$ + AA	421.63 f	408.23 f	38.22 d	39.08 e	4611 d	4808 e
Fridor	1.NPK 100%	304.11 o	320.65 m	25.89 j	28.27 m	4316 h	4410 k
	2.NPK 50%	270.15 r	268.10 q	20.18 n	23.65 q	4136 k	4250 n
	3.NPK$_{50\%}$ + HA	281.32 q	360.18 j	25.11 l	32.60 i	4536 f	4710 g
	4.NPK$_{50\%}$ + SW	298.67 p	420.22 e	26.30 i	39.17 e	4753 c	4810 e
	5.NPK$_{50\%}$ + AA	268.63 r	352.07 k	23.72 m	32.00 j	4522 f	4653 h
Oceania	1.NPK 100%	432.36 d	340.18 l	38.82 c	31.62 k	4328 h	4528 j
	2.NPK 50%	396.72 i	296.15 o	31.14 g	26.32 o	4255 i	4280 m
	3.NPK$_{50\%}$ + HA	426.91 e	436.27 cd	38.06 d	40.06 d	4800 b	4870 c
	4.NPK$_{50\%}$ + SW	428.89 e	441.18 c	38.25 d	42.18 c	4818 b	4886 bc
	5.NPK$_{50\%}$ + AA	400.11 h	398.27 g	33.62 f	38.50 f	4603 d	4793 ef

Means followed by the same letter (s) within each column do not significantly differ using Duncan's Multiple Range Test at the level of 5%.
HA: Humic acid; SW: Seaweed extract; AA: Amino acids

Stimulants.

Organic stimulators were applying to improve different performances of potatoes under a biotic stressful condition (cold stress).

The presented data in Table 3 prove that, organic stimulators when applied with 50% of NPK-fertilizer gave rise to significant increase in all growth parameters (fresh weight, dry weight and leaf area) of their plants over those of the control treatment (100% NPK) or half dose of mineral fertilizer (50% NPK), in the two seasons of this study. Among them the most effective and considerably growth enhancement ones were SW + 50% NPK, in both seasons (except for, fresh weight on 1st season).

These results may be due to the beneficial effect of seaweed extracts contain naturally occurring supplying nutrients, plant growth hormones (auxins, cytokinins and gibberellins) as well as other plant growth biostimulants (e. g., amino acids, vitamins and betaines) which can maintain photosynthetic rates, improve plant resistances, delay leaf senescence and control cell division (Blunden *et al*., 1986; Rhodes and Hanson, 1993; Fike *et al*., 2001).

Interaction.

Regarding the interaction effect, data in the same Table (Table 3) illustrate that, Spunta cv. treated with SW + 50% NPK gave significant increase in fresh weight, dry weight, leaf area per plant compared with other treatments, in both seasons of study.

Regardless the direct adverse effects of cold temperature extremes, recently it was known that this condition and others induce serious internal physiological oxidative stress, enhance the accumulation of reactive oxygen species ROS in high toxic and destructive level (Bowler *et al* 1992; Dat *et al*., 2000). This followed by serious destructive internal events of cell membrane peroxidation, protein oxidation , enzymes inhibition, and DNA & RNA damage (Dat *et al*., 2000; Mittler , 2002).

Such probable cold stress induce oxidative destructive which explain the low growth, in case of the control plants (100% NPK) or 50% of the recommended NPK, in comparison with the plants of other treatments grown under the same condition.

Supperession of the accumulated ROS could greatly protect against cold extremes (Keit *et al*., 2000).The applying of SW may suppress the level and action of cold-oxidative effects (Zhang *et al*., 2003; Palta and Karim, 2006).

Yield and yield components:

Cultivars.

The effect of potato cultivars on total tuber yield and yield components, data presented in Table 4 indicate that the highest increments in values of total tuber yield, number of tuber per plot, average tuber weight and tuber weight over 50 mm were obtained in case of using Spunta and Oceania cv$_s$. On the other hand, Alaska cv. gave the lowest values in this respect. Meanwhile, Fridor cv. gave the highest values in tuber weight (%) over 50 mm as compared with other cv$_s$.

Generally, it may be concluded that the differences in total tuber yield among cultivars were mainly due to the differences of genetical constitution for these cultivars and their response to the environmental condition prevailing during growth period.

Stimulants.

Regarding the effect of organic stimulators, data presented in Table 4 also indicate that foliar application of SW + addition of 50% NPK significantly increased all the studied yield characters, i.e., total tuber yield per feddan, number of tuber per plant, average tuber weight and tuber weight over 50 mm (ton fed^{-1} & %). The percentage increases over the control (NPK 100%) reached to 14.78, 18.29%, in both seasons, respectively. The second treatment regarding the increase in tuber yield and yield components was HA + NPK 50%. On the other hand, the lowest tuber yield was recorded under the treatment of 50% of recommended NPK, in two seasons of study.

Seaweeds are considered as an important source of organic matter. Their effects on yield and its components could be through their content of amino acids, micronutrients, vitamins, hormones (esp., cytokinins) and betaines leading to stimulation of plant growth (higher biomass production, Table 3) and consequently on total tuber yield and its components (Blunden *et al*., 1986; Fike *et al*. 2001; Zhang *et al*., 2003). These results are in agreement with those obtained by Blunden and Wildgoose (1977), Lung (1996), Lopez-Mosquera and Pazoas (1997), Riley (2002), and Rana *et al*. (2006) on potato plants.

Once again, the growth promoting substances in fresh algae have been studied and well-documented. Recent research suggests the presence of an auxin like, gibberellins like, and cytokinins like hormone in the seaweed extracts (Blunden and Wildgoose, 1977; Zhang and Ervin, 2004; Khan *et al*., 2009). The benefit of seaweed extracts could arise from physiological changes in the internal structure of plant cells which could be induced by the high contents of the micro-nutrients in the seaweed extracts (Khan *et al*., 2009). Research results showed a significant increase over the control in soluble solids of field grown tomato, in protein content of soybean, and in insoluble solids of Concord grape when plants were sprayed with seaweed extracts (SAFA, 2009).

Interaction.

Data presented in Table 4 demonstrate also the effect of various treatments of cultivars and organic stimulators+NPK on tuber yield and yield components of potato plants. Significant effects on total tuber yield, number of tuber per plot, average tuber weight, tuber weight over 50 mm (per feddan & %) were obtained under the treatment where NPK 50% plus foliar application of SW was applied in comparison with other treatments, in both seasons of study. The second treatment regarding the increase in tuber yield and yield components was NPK 50% + HA.

Aveline (2011) found that polyamine compounds in seaweed also play a role in cold resistance as does abscisic acid. Seaweed as a plant supplement treatment has consistently proved to be the best treatment for preventing the threat of frost damage.

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Also, Humic acids are considered as an important source of organic matter and their effects on yield and its components could be due to their effect on increasing soil moisture holding capacity, improving soil texture as well as the uptake of nutrients leading to stimulation of plant growth (higher biomass production) and consequently on total tuber yield and its components (Chen and Avaid, 1990; Mikkelsen, 2005). Similar results were found by Seyedbagheri and Torell (2001).

Under present work conditions the obvious reduced reproductive performance of the control plants relative to other treatments , could be expected as a result of day and night temperature extremes (Table 2) that reduced the optimum ones (25 / 15^o C) for the reproductive activities (vegetative growth, tuberization and ripening) (Ewing, 1997). These minimum temperature known to be consequence by severe abscission of reproductive sinks, poor tuberization and low productivity (Ewing, 1997). On the other hand, the enhancement effect of the organic stimulators treatments could be explained based on their beneficial effect in similar trend on all growth parameters (Table 3). Also, may be due to their antioxidantal protective role in preventing the cold oxidative damage of the genetical materials, signaling certain genetical defensive responses, avoiding the cold oxidative inhibition of the transporter and biosynthesis enzymes, maintaining cell membrane stability and functions (Bowler *et al* 1992; Dat *et al*., 2000).

Tuber quality:

Cultivars.

Data in Table 5 indicated that, tubers of Fridor and Oceania cv$_s$ were significantly higher in dry matter, specific gravity and starch content and lower reducing sugars than of Spunta and Alaska cultivars in the two seasons.

Stimulants.

Data of Table 5 also show that treatments of tested HA, SW and AA had direct effect on tuber quality. Spraying potato plants with HA or SW+ addition of 50% of inorganic fertilizer NPK significantly increased tuber dry matter, specific gravity and starch and reduced significantly reducing sugars, compared with other treatments, in both seasons.

A humic acid is excellent foliar fertilizer carriers and activators. Application of humic acids, as foliar sprays, can improve the growth of plant foliage, roots, and tubers. By increasing plant growth processes within the leaves an increase in carbohydrates content of the leaves and stems occurs (Stevenson, 1994). These carbohydrates are then transported down into the tubers where they are in part released from the root to provide nutrients for various soil microorganisms on the rhizoplant and in the rhizosphere (Chen and Avid, 1990). The microorganisms then release acids and other organic compounds which increase the availability of plant nutrients. Other microorganisms release "hormone like" compounds which are taken up by plant roots (Zhang *et al*., 2003). In addition to the rich nutrients, vitamins, kahydrin and PGRs, seaweed contains natural chelating agents, primarily mannitol which chelating micronutrients in soil to eliminate minor deficiencies, and thus, these turn reflect on tuber quality (Spinelli *et al*., 2010; Aveline, 2011).

Interaction.

As for the interaction effects on tuber quality, results in Table 5 show significant differences among treatments, in this respect. Application of humic acid as foliar spray to potatoes under 50% of NPK significantly increased tuber dry matter, specific gravity and starch content and significantly decreased reducing sugar, in comparison with other treatments, in both season of study. The result may be due to increase of availability of elements and water holding capacity, consequently increasing their absorption by plant and transfer to the storage part (tubers) as reported by Salib (2002). Similar finding were obtained by Ezzat *et al*. (2009).

Chemical composition of potato tubers:

Cultivars.

Data presented in Table 6 show that, there were significant differences among cultivars in tuber NPK contents, and nitrate as well as nitrite content in potato tuber, in both seasons. The highest values in NK-uptake were obtained via using Fridor followed by Oceania cv_s. Meanwhile, there were insignificant differences among cv_s in P-uptake. This is true in two seasons of study. Similar results were found by Conley *et al*., 2001.

In both seasons, Spunta cv. produced higher nitrate content than other cv_s (Table 6), but significant differences among cultivars were very low. On the other had, there were insignificant differences among cv_s in nitrite content, in both seasons. Similar results were found by Ierna (2009) who reported that investigated varieties differed in nitrate content, in both off-season crops, the highest quantities of nitrate were contained in the late Mondial, with respect to the middle early Arinda variety and Spunta

Stimulants.

The addition of humic acid significantly increased all the studied chemical constituents of potato tubers (NPK-content) and significantly reduced nitrate and nitrite content in potato tuber (Table 6)**.**

The increment in NPK-uptake may be due to that HA is extremely important component because it constitutes a stable fraction of carbon, thus regulating the carbon cycle and release of nutrients, including nitrogen, phosphorus, and potassium, which decreasing the need for inorganic fertilizer for plant growth. HA stimulate plant growth by the assimilation of major and minor elements, enzyme activation and/or inhibition, changes in membrane permeability, protein synthesis and finally the activation of biomass production (Ulukon, 2008). Moreover, Russo and Berlyn (1990) reported that, humates (granular and liquid forms) can reduce plant stress that involved plant diseases as well as enhance plant nutrient uptake. HA contributes significantly to water retention and metal/solute binding and release, and they are necessary for safe plant nutrition (Stevenson, 1994; MacCarthy *et al*., 1990). In addition, HA can be used as a growth regulator by regulate endogenous hormone levels (Piccolo *et al*., 1992; Frgbenro and Agboola, 1993).

Interaction.

With respect to the interaction between cultivars and organic stimulators, it is evident from the data in Table 6 that all tuber chemical composition; i.e., NPK-uptake and nitrate and nitrite contents were significantly affected by the interaction treatments.

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Application of HA + NPK 50% significantly increased NPK-uptake and significantly decreased NO_3^- and NO_2^- contents.

Humic substances will maximize the efficient use of residual plant nutrients, reduce fertilizer costs, and help release those plant nutrients presently bound is minerals and salts (Liu *et al*., 1998; Zhang *et al*., 2003).

Superoxide dismutase activity:

The results of this study indicate that Spunta and Oceania cv_s generally increased SOD activity of field grown potatoes, in both seasons of study (Fig. 1 & 2). These increases were associated with greater biomass and tuber productivity (Tables, 4 and 5).

Application of HA or SW plus 50% of recommended NPK increased SOD activity by 49.41 and 40.49% (1st season) and 38.67% and 45.83% (2nd season), over full dose of NPK, respectively (Fig. 3 & 4).

These results are consistent with those of Fike *et al*. (2001); Zhang and Schmidt (2000) and Zhang *et al*. (2003). Our results indicate that increased SOD activity due to HA or SW application may have improved potato physiology health to cold stress. Yan *et al*. (1997) reported that SW increased membrane lipid unsaturation and fluidity leading to more favorable perennial ryegrass leaf water potential under drought.

The potato cv_s x organic stimulators interaction was not significant for SOD activity in both seasons of study.

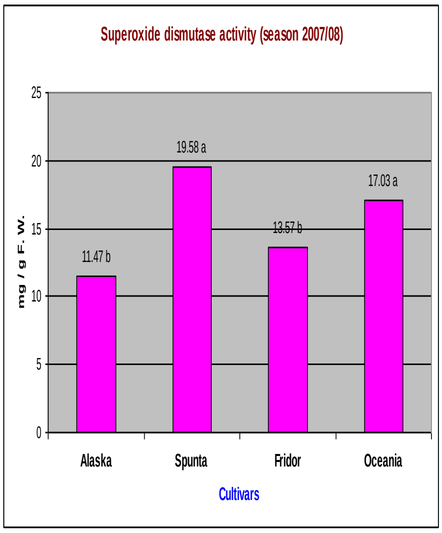

Fig 1: Superoxide dismutase activity of potato tubers as affected by different cultivars during 1st season of study.

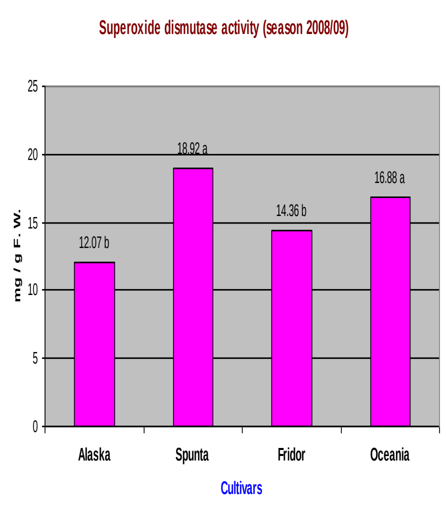

Fig 2: Superoxide dismutase activity of potato tubers as affected by different cultivars during 2nd season of study.

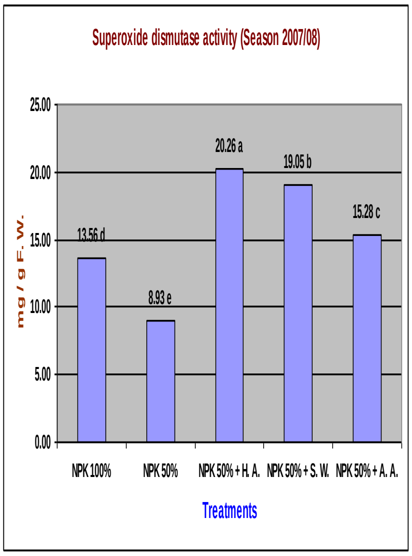

Fig 3: Superoxide dismutase activity of potato tubers as affected by NPK + organic stimulators treatments during 1st season of study.

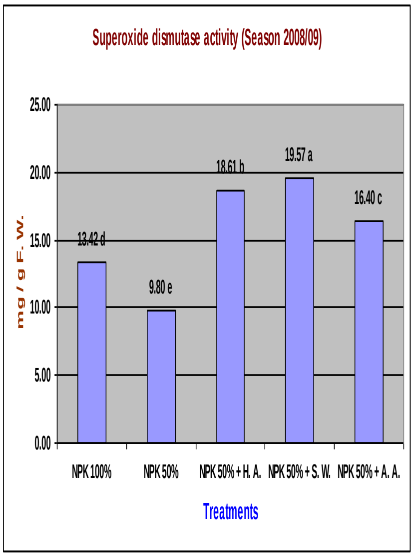

Fig 4: Superoxide dismutase activity of potato tubers as affected by NPK + organic stimulators treatments during 2nd season of study.

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تحسين المحصول والجودة لبعض أصناف البطاطس الجديدة في الزراعات الشتوية باستخدام المنشطات العضوية

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أجري هذا البحث بغرض دراسة استخدام بعض المنشطات العضوية مثل الأحماض الهيومية ومستخلص أعشاب البحر والأحماض الأمينية علي بعض أصناف البطاطس الجديدة عند زراعتها في عروة شتوية متأخرة - درجات حرارة منخفضة - بغرض أطالة موسم التصدير.. حيث تقوم هذه المنشطات العضوية بمعادلة free radicals في الخلايا والأنسجة النباتية مؤدية في النهاية الي زيادة حفز تحمل نباتات البطاطس لظروف اجهادات الحرارة المنخفضة، و تأثير ذلك علي النمو وتحسين الأنتاجية ونشاط أنزيم سوبر أكسيد ديسميوتاز SOD، والذي يعتبر دليل لمقاومة أجهادات البرودة، كما يهدف البحث أيضا الي تقليل الأعتماد علي الأسمدة الكيماوية.

ولتحقيق هذه الأغراض نفذت تجربتان حقليتان فى المزرعة البحثية بالبرامون - المنصورة – محافظة الدقهلية لدراسة استجابة بعض أصناف البطاطس الجديدة مثل: الأسكا، فرايدور، أوسانيا بالأضافة الي صنف اسبونتا لبعض المنشطات العضوية مع السماد المعدني ن فو بو كالتالي: ١- سماد معدني ١٠٠%، ٢- سماد معدني ٥٠%، ٣- سماد معدني ٥٠% + حامض هيوميك، ٤- سماد معدني ٥٠% + مستخلص أعشاب البحر،و ٥- سماد معدني ٥٠% + أحماض أمينية. تمت زراعة هذه الأصناف بدرنات كاملة في منتصف شهر نوفمبر خلال الموسمين الشتويين ٢٠٠٧/٢٠٠٨ و ٢٠٠٨/٢٠٠٩.

وقد أظهرت النتائج ما يلي:

- اختلفت أصناف البطاطس محل الدراسة في كل الصفات المدروسة، وكان أكثرها تأثيرا معنويا صنف سبونتا وذلك في صفات الوزن الطازج والجاف للنبات ،المساحة الورقية، المحصول الكلي، عدد الدرنات/بلوت، متوسط وزن الدرنة، وكذلك محتوي النترات في الدرنة ونشاط أنزيم SOD، يليه في التأثير صنف أوسانيا مقارنة بالصنفين الأخرين وذلك في موسمي الدراسة. وعلي الجانب الأخر فقد تفوق صنف فرايدور وكذلك صنف أوسانيا معنويا في صفات جودة الدرنات المتمثلة في المادة الجافة، الكثافة النوعية، نسبة النشا، ومحتوي الدرنات من النتروجين والبوتاسيوم. بينما لم تسجل اية فروق معنوية بين الأصناف في محتوي الدرنات من الفوسفور والنيتريت. بينما أعطي صنف الأسكا أعلي محتوي من السكريات المختزلة في درناته.
- تفوقت المعاملة بمستخلص أعشاب البحر + ٥٠% من المعدل الموصي به من السماد المعدني في معظم الصفات محل الدراسة مثل: الوزن الطازج، والوزن الجاف، المساحة الورقية، المحصول الكلي، عدد الدرنات/بلوت، متوسط وزن الدرنة، ووزن الدرنات > ٥٠ مم في موسمي الدراسة مقارنة بباقي المعاملات. بينما أعطت معاملة الرش الورقي بحامض الهيوميك او مستخلص أعشاب البحر + ٥٠% من السماد المعدني تفوقا معنويا في صفات جودة الدرنات (المادة الجافة، الكثافة النوعية، نسبة النشا)، ونقصا معنويا في نسبة السكريات المختزلة في الدرنات. بينما سجلت المعملة بحامض الهيوميك فقط + ٥٠% من السماد المعدني أعلي محتوي من ن فو بو في الدرنات (موسمي الدراسة)، وكذلك أنزيم SOD (الموسم الأول). وبصفة عامة أعطت المنشطات العضوية أقل محتوي من النترات والنيتريت في الدرنات مقارنة بالسماد المعدني.
- أثر التفاعل بين عاملي الدراسة (الأصناف x المنشطات العضوية) معنويا علي جميع الصفات المدروسة في كلا الموسمين، وكانت أكثر المعاملات تأثيرا معنويا الرش الورقة بمستخلص أعشاب البحر + ٥٠% من السماد المعدني علي صنف سبونتا، الرش الورقي بحامض الهيوميك + ٥٠% من السماد المعدني علي صنف فرايدور.

وخلصت الدراسة الي أنه يمكن رش حقول البطاطس في العروة الشتوية (منتصف نوفمبر) بالمنشطات العضوية وفي وجود ٥٠% من السماد المعدني لمقاومة اجهادات البرودة في هذه العروة مع تحسين الإنتاجية والجودة وتقليل الأسمدة المعدنية بنسبة ٥٠%.

قام بتحكيم البحث

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Table 4: Total tuber yield and yield components of potato as affected by varieties, NPK plus organic stimulators and their interactions in 2007/08 and 2008/09 seasons.

Treatments		Tuber yield (ton/fed.)		No. tubers/plot		Average tuber weight (g)		Tuber weight > 50 mm (ton/fed.)		Tuber weight > 50 mm (%)	
		2007/08	2008/09	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09
Varieties:-											
1.Alaska		9.472 d	9.249 c	154.00 d	157.93 c	153.46 b	145.69 b	8.150 c	8.136 c	85.69	87.90
2.Spunta		11.412 a	11.280 a	179.60 a	184.27 a	158.45 a	152.96 a	10.548 a	10.480 a	92.17	92.71
3.Fridor		10.120 c	10.031 bc	162.00 c	168.33 bc	155.97 ab	149.26 ab	9.696 b	9.702 c	95.78	96.15
4.Oceania		10.764 b	10.616 ab	171.13 b	176.13 ab	157.05 a	149.44 ab	10.322 a	10.116 ab	95.98	95.21
NPK + Organic stimulators:-											
1.NPK 100%		10.150 d	9.663 d	160.50 d	163.75 c	158.21 b	148.15 c	9.280 d	8.955 d	91.48	91.87
2.NPK 50%		8.160 e	8.530 e	145.42 e	151.33 d	147.95 d	140.79 d	7.818 e	7.780 e	90.60	91.10
3.NPK$_{50\%}$ + HA		11.400 b	11.210 b	179.42 b	183.58 a	158.77 b	152.53 ab	10.615 b	10.563 b	92.92	94.10
4.NPK$_{50\%}$ + SW		11.650 a	11.430 a	181.75 a	185.75 a	160.05 a	153.81 a	11.095 a	10.795 a	95.19	94.35
5.NPK$_{50\%}$ + AA		10.400 c	10.637 c	166.33 c	175.00 b	156.18 c	151.42 b	9.600 c	9.950 c	91.85	93.53
Interaction:-											
Alaska	1.NPK 100%	9.600 k	8.060 n	151.00 k	142.00 m	158.94 c	141.90 ef	8.440 n	6.980 m	87.92	86.60
	2.NPK 50%	8.000 n	7.680 o	141.00 n	140.33 m	141.84 k	136.82 g	6.450 n	6.600 n	80.63	85.94
	3.NPK$_{50\%}$ + HA	10.400 hi	10.400 hi	165.33 h	172.00 fgh	157.26 def	151.16 abc	8.880 m	9.360 i	85.38	90.00
	4.NPK$_{50\%}$ + SW	10.560 h	10.620 gh	168.33 g	174.33 e-h	156.83 ef	152.30 abc	9.740 i	9.480 hi	92.23	89.27
	5.NPK$_{50\%}$ + AA	8.800 lm	9.420 jk	144.33 m	161.00 jk	152.43 h	146.27 de	7.240 q	8.260 k	82.27	87.69
Spunta	1.NPK 100%	10.960 fg	11.260 e	176.67 e	181.67 de	155.09 g	154.95 a	9.640 j	10.120 f	87.96	89.88
	2.NPK 50%	9.040 l	9.240 k	148.33 l	158.67 k	152.36 h	145.56 de	8.140 p	8.280 k	90.04	89.61
	3.NPK$_{50\%}$ + HA	12.620 b	12.040 ab	196.33 a	196.00 ab	160.70 b	153.57 abc	11.920 b	11.500 ab	94.45	95.51
	4.NPK$_{50\%}$ + SW	13.040 a	12.260 a	195.33 a	198.00 a	166.90 a	154.80 a	12.400 a	11.660 a	95.09	95.11
	5.NPK$_{50\%}$ + AA	11.400 e	11.600 cd	181.33 d	187.00 cd	157.17 ef	155.91 a	10.640 e	10.840 d	93.33	93.45
Fridor	1.NPK 100%	10.040 j	10.000 j	159.00 i	167.33 hij	157.86 c-f	149.41 bcd	9.440 l	9.600 h	94.02	96.00
	2.NPK 50%	8.600 m	8.400 m	145.67 lm	150.00 l	147.59 j	140.00 fg	8.240 o	8.000 l	95.81	95.24
	3.NPK$_{50\%}$ + HA	10.800 g	10.800 fg	170.67 g	176.00 efg	158.20 cde	153.00 abc	10.360 g	10.320 e	95.93	95.56
	4.NPK$_{50\%}$ + SW	10.960 fg	11.040 ef	174.00 f	178.33 ef	157.47 c-f	154.77 a	10.640 f	10.720 d	97.08	97.10
	5.NPK$_{50\%}$ + AA	10.200 ij	10.180 i	160.67 i	170.67 ghi	158.71 cd	149.12 cd	9.800 h	9.860 g	96.08	96.86
Oceania	1.NPK 100%	10.000 j	9.600 j	155.33 j	164.00 ijk	160.94 b	146.34 de	9.600 k	9.120 j	96.00	95.00
	2.NPK 50%	8.800 lm	8.800 l	146.67 lm	156.33 kl	150.00 i	140.73 fg	8.440 n	8.240 k	95.91	93.64
	3.NPK$_{50\%}$ + HA	11.780 d	11.600 cd	185.33 c	190.33 bc	158.90 c	152.37 abc	11.300 d	11.060 c	95.93	95.34
	4.NPK$_{50\%}$ + SW	12.040 c	11.800 bc	189.33 b	192.33 abc	158.98 c	153.38 abc	11.600 c	11.320 b	96.35	95.93
	5.NPK$_{50\%}$ + AA	11.200 ef	11.280 de	179.00 de	182.00 de	156.42 fg	154.37 ab	10.720 e	10.840 d	95.71	96.10

Means followed by the same letter (s) within each column do not significantly differ using Duncan's Multiple Range Test at the level of 5%.
HA: Humic acid; SW: Seaweed extract; AA: Amino acids

Table 5: Tuber quality of potato as affected by varieties, NPK plus organic stimulators and their interactions in 2007/08 and 2008/09 seasons.

Treatments		Tuber dry matter (%)		Specific gravity of tubers		Starch (%)		Reducing sugars (%)	
		2007/08	2008/09	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09
Varieties:-									
1.Alaska		20.60 b	20.78 c	1.0744 b	1.0743 c	13.27 b	12.95 b	0.418 a	0.315 a
2.Spunta		21.22 b	21.47 bc	1.0795 b	1.0821 b	13.75 b	13.55 b	0.387 a	0.276 b
3.Fridor		22.54 a	22.67 a	1.0924 a	1.0925 a	15.21 a	15.16 a	0.248 b	0.163 c
4.Oceania		22.19 a	22.35 ab	1.0896 a	1.0899 a	14.97 a	14.96 a	0.290 b	0.187 c
NPK + Organic stimulators:-									
1.NPK 100%		21.31 d	21.67 b	1.0808 b	1.0833 b	14.04 bc	13.99 bc	0.378 a	0.277 a
2.NPK 50%		21.26 d	21.53 b	1.0814 b	1.0830 b	13.97 c	13.89 c	0.366 a	0.261 b
3.NPK$_{50\%}$ + HA		21.93 b	22.07 a	1.0865 a	1.0871 a	14.56 a	14.42 ab	0.310 c	0.213 cd
4.NPK$_{50\%}$ + SW		22.05 a	22.20 a	1.0867 a	1.0876 a	14.66 a	14.50 a	0.300 c	0.202 d
5.NPK$_{50\%}$ + AA		21.64 c	21.64 b	1.0846 a	1.0828 b	14.28 b	13.98 bc	0.326 b	0.225 c
Interaction:-									
Alaska	1.NPK 100%	20.43 k	20.65 mn	1.0720 k	1.0728 k	13.18 h	12.78 fg	0.452 a	0.368 a
	2.NPK 50%	20.22 l	20.38 n	1.0746 jk	1.0732 k	13.10 h	12.60 g	0.441 ab	0.341 b
	3.NPK$_{50\%}$ + HA	20.81 ij	20.93 lm	1.0753 ijk	1.0756 k	13.36 gh	13.11 fg	0.400 def	0.292 def
	4.NPK$_{50\%}$ + SW	20.90 i	21.08 kl	1.0762 h-k	1.0762 jk	13.42 fgh	13.26 fg	0.390 ef	0.276 efg
	5.NPK$_{50\%}$ + AA	20.63 j	20.86 lm	1.0738 jk	1.0741 k	13.28 gh	13.00 fg	0.408 cde	0.300 cde
Spunta	1.NPK 100%	21.00 hi	21.26 jk	1.0770 hij	1.0800 ij	13.62 fgh	13.41 fg	0.432 abc	0.328 bc
	2.NPK 50%	21.10 h	21.30 ijk	1.0785 g-i	1.0810 hi	13.58 fgh	13.36 fg	0.420 bcd	0.311cd
	3.NPK$_{50\%}$ + HA	21.12 h	21.48 hij	1.0800 ghi	1.0822 ghi	13.70 fgh	13.56 efg	0.362 gh	0.250 gh
	4.NPK$_{50\%}$ + SW	21.50 fg	21.73 fgh	1.0818 fg	1.0841 e-i	14.00 ef	13.80 def	0.341 hi	0.228 hi
	5.NPK$_{50\%}$ + AA	21.40 g	21.60 ghi	1.0803 gh	1.0833 f-i	13.85 efg	13.72 def	0.380 fg	0.265 fg
Fridor	1.NPK 100%	22.00 d	22.57 b	1.0881 de	1.0930 abc	14.70 cd	15.10 abc	0.300 kl	0.200 ijk
	2.NPK 50%	22.10 d	22.43 bc	1.0892 cde	1.0911 bcd	14.80 cd	15.00 abc	0.291 kl	0.190 jkl
	3.NPK$_{50\%}$ + HA	23.18 a	23.26 a	1.0980 a	1.0974 a	15.80 a	15.73 a	0.200 p	0.132 o
	4.NPK$_{50\%}$ + SW	23.00 a	23.22 a	1.0950 ab	1.0960 a	15.62 ab	15.58 ab	0.218 op	0.143 no
	5.NPK$_{50\%}$ + AA	22.43 c	21.86 efg	1.0918 bcd	1.0852 e-h	15.15 bc	14.40 cde	0.232 no	0.151 mno
Oceania	1.NPK 100%	21.80 e	22.18 cde	1.0860 ef	1.0872 def	14.65 cd	14.65 bcd	0.328 ij	0.213 ij
	2.NPK 50%	21.63 ef	22.00 def	1.0832 fg	1.0865 efg	14.40 de	14.60 bcd	0.310 jk	0.200 ijk
	3.NPK$_{50\%}$ + HA	22.62 b	22.60 b	1.0928 bcd	1.0930 abc	15.38 ab	15.30 abc	0.276 lm	0.176 klm
	4.NPK$_{50\%}$ + SW	22.80 b	22.76 b	1.0936 abc	1.0941 ab	15.60 ab	15.41 abc	0.252 mn	0.162 lmn
	5.NPK$_{50\%}$ + AA	22.10 d	22.23 cd	1.0927 bcd	1.0886 cde	14.82 cd	14.80 abc	0.283 kl	0.182 kl

Means followed by the same letter (s) within each column do not significantly differ using Duncan's Multiple Range Test at the level of 5%.
HA: Humic acid; SW: Seaweed extract; AA: Amino acids

Table 6: NPK and nitrate and nitrite contents of potato tubers as affected by varieties, NPK plus organic stimulators and their interactions in 2007/08 and 2008/09 seasons.

Treatments		N-uptake (mg/100 D. W.)		P-uptake (mg/100 D. W.)		K-uptake (mg/100 D. W.)		NO$_3^-$ content (mg/ kg F. W.)		NO$_2^-$ content (mg/ kg F. W.)	
		2007/08	2008/09	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09
Varieties:-											
1.Alaska		592.61 b	591.42 c	71.30 a	71.68 a	812.74 b	930.48 a	53.13 a	54.90 a	0.51 a	0.50 a
2.Spunta		666.87 b	676.11 b	72.88 a	72.18 a	936.53 b	980.72 a	48.98 ab	50.77 ab	0.48 a	0.46 a
3.Fridor		831.85 a	803.43 a	77.10 a	77.36 a	1220.89 a	1074.52 a	45.55 b	48.53 ab	0.45 a	0.43 a
4.Oceania		803.64 a	775.69 a	75.66 a	74.51 a	1138.20 a	1037.55 a	44.11 b	47.44 b	0.44 a	0.42 a
NPK + Organic stimulators:-											
1.NPK 100%		683.15 c	678.17 c	63.18 d	63.34 d	944.39 c	851.42 c	64.41 a	63.27 a	0.63 a	0.60 a
2.NPK 50%		665.54 d	654.51 c	53.68 e	53.89 e	930.48 c	771.68 d	56.83 b	57.72 b	0.54 b	0.52 b
3.NPK$_{50\%}$ + HA		771.97 a	749.81 a	93.42 a	92.92 a	1113.05 a	1247.39 a	32.21 e	39.60 d	0.39 d	0.34 d
4.NPK$_{50\%}$ + SW		770.24 b	754.89 a	85.24 b	84.60 b	1108.80 a	1212.95 a	37.06 d	39.37 d	0.34 e	0.34 d
5.NPK$_{50\%}$ + AA		727.81 b	720.93 b	75.66 c	74.93 c	1038.74 a	945.65 a	49.23 c	52.09 c	0.47 c	0.47 c
Interaction:-											
Alaska	1.NPK 100%	580.20 kl	572.13 ij	60.30 k	62.11 ij	792.66 k	830.08 i-l	67.22 a	65.40 a	0.65 a	0.62 a
	2.NPK 50%	571.13 l	560.73 j	50.73 k	52.38 k	788.28 k	732.11 l	60.78 bcd	60.18 bcd	0.58 bc	0.55 abc
	3.NPK$_{50\%}$ + HA	610.33 ij	620.33 ij	90.18 b	89.72 bcd	862.18 ijk	1110.22 ef	44.62 j	46.50 i	0.42 hij	0.40 ghi
	4.NPK$_{50\%}$ + SW	603.22 jk	613.67 ij	85.20 cd	84.13 de	827.20 jk	1076.82 fg	41.70 ij	48.72 ij	0.42 hij	0.42 f-i
	5.NPK$_{50\%}$ + AA	598.17 jkl	590.22 ij	70.10 g	70.08 gh	800.07 k	903.18 hij	51.34 fgh	53.70 fgh	0.50 def	0.48 c-f
Spunta	1.NPK 100%	631.84 i	670.10 h	62.33 hi	62.00 ij	911.67 hij	841.76 i-l	65.22 ab	63.18 ab	0.63 ab	0.60 ab
	2.NPK 50%	610.65 ij	615.23 i	52.18 l	52.18 k	890.22 h-k	750.60 kl	58.13 cde	58.20 cde	0.55 cd	0.53 bcd
	3.NPK$_{50\%}$ + HA	680.28 h	680.00 h	92.13 b	91.83 abc	943.78 hi	1210.22 cde	38.80 lm	38.00 lm	0.40 ijk	0.33 jkl
	4.NPK$_{50\%}$ + SW	701.30 gh	700.05 gh	82.33 de	80.17 ef	960.72 ghi	1180.70 def	32.11 k	42.30 k	0.36 kl	0.38 hij
	5.NPK$_{50\%}$ + AA	710.26 fg	715.15 gh	75.41 f	74.13 g	976.28 gh	920.30 hi	50.62 ghi	52.19 ghi	0.48 efg	0.48 c-f
Fridor	1.NPK 100%	780.33 d	745.32 efg	65.00 h	65.08 hi	1083.11 ef	880.16 hij	63.00 abc	61.50 abc	0.62 ab	0.58 ab
	2.NPK 50%	750.21 e	736.76 fg	56.20 j	57.20 jk	1060.70 efg	793.26 jkl	54.30 def	57.33 def	0.52 de	0.51 cde
	3.NPK$_{50\%}$ + HA	922.16 a	880.67 a	96.18 a	96.00 a	1390.13 a	1370.28 a	34.72 kl	40.70 kl	0.38 jkl	0.36 ijk
	4.NPK$_{50\%}$ + SW	896.23 b	862.13 ab	87.23 c	88.18 cd	1352.20 ab	1342.16 ab	26.80 o	31.02 o	0.28 n	0.26 m
	5.NPK$_{50\%}$ + AA	810.31 c	792.26 cde	80.88 e	80.33 ef	1218.32 cd	986.73 gh	48.62 ghi	52.08 ghi	0.46 fgh	0.46 d-g
Oceania	1.NPK 100%	740.23 e	725.13 gh	65.10 h	64.17 i	990.10 fgh	853.66 ijk	62.18 ab	63.00 ab	0.60 ab	0.60 ab
	2.NPK 50%	730.18 ef	705.30 gh	55.61 j	53.78 k	982.73 fgh	810.74 i-l	53.76 efg	55.18 efg	0.52 de	0.49 c-f
	3.NPK$_{50\%}$ + HA	875.10 b	818.22 bcd	95.20 a	94.11 ab	1256.11 bcd	1298.82 abc	30.08 no	33.20 no	0.34 lm	0.28 lm
	4.NPK$_{50\%}$ + SW	880.21 b	843.72 abc	86.18 c	85.32 de	1301.76 abc	1252.12 bcd	28.23 mn	35.42 mn	0.31 mn	0.31 klm
	5.NPK$_{50\%}$ + AA	792.50 cd	786.10 def	76.23 f	75.16 fg	1160.30 de	972.60 gh	46.33 hij	50.40 hij	0.44 ghi	0.44 e-h

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HA: Humic acid; SW: Seaweed extract; AA: Amino acids